THE UNITED STATES GEOLOGICAL SURVEY IN 1894.

BY

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The year 1894 was a noteworthy one for the U. S. Geological Survey. One important event distinguishes it from all previous years. In May, 1894, Major J. W. Powell, who had directed its affairs almost from the beginning, in 1879, resigned, and was succeeded by Mr. Charles Doolittle Walcott. A change of bureau chiefs in Washington is too common an event to be ranked as noteworthy, but with the scientific work of the government the case is different. The retirement in the past, of such men as Henry and Baird from the Smithsonian, Hassler and Bache from the Coast Survey, and quite recently of Mendenhall from the Coast Survey, and Powell from the Geological Survey, profoundly affect the bureaus and work directed by them. The work of scientific research, of enlarging the bounds of human knowledge, is not one that goes by routine. To so direct such work that useful results may be acquired for the people and for science requires peculiar qualities. For the geologic branch of this task the successful director must not only be versed in the knowledge already gained respecting the surface and structure of our earth, must not only know the directions in which new and valuable results are to be sought, but must have wide acquaintance with men and affairs, and be an efficient executive. Looking outward, he must be able to clearly present to Congress and the country results already obtained with clear plans and projects for yet other results to be sought for, and looking inward to the administration of his office he must be able to co-ordinate and harmonize the labors of the various scientific co-laborers who constitute his somewhat "cranky" household.

To clearly place the work of 1894 in its proper setting, it will be found useful to summarize the work from the beginning in 1879, down to July 1, 1894, when the present director, Mr. Walcott, formally began the conduct of its affairs.

The U. S. Geological Survey created by act of March 3, 1879, arose from the consolidation and reorganization of three pre-existing surveys, all of which had for a number of years been conducting surveys in the Far West. The first director, Mr. Clarence King, directed its affairs for two years, March, 1879, to March, 1881, when its administrative burden led him to resign, and he was suc-

ceeded by Major J.W. Powell, who directed its affairs for 13 years, March, 1881, to June, 1894. Under him the Survey began to grow rapidly, too rapidly, his critics said, when the appropriation began to grow. At first its operations were confined to the Far West, to the Rocky Mountains and beyond. But a debate arose in Congress very early as to why surveys and geologic researches made for all the people and paid for by all the people should be restricted to only one part of the country. The survey had been created to investigate "the geological structure, mineral resources and products of the national domain," and the representatives from the Central and Eastern States pertinently inquired whether their part of the United States was not a part of the *national domain.* The outcome of the debate was a decision by vote of Congress that the field to be investigated was not merely the little known West, but the whole extent of the United States. Thus, in 1883, work began in the Appalachian Mountains, a region which, despite its long settlement, was hardly so well known geographically and geologically as many of our western mountains.

One of the first and most urgent needs for the profitable and economic prosecution of geologic work is maps, topographic maps, maps showing the configuration of the land surface as well as the towns, roads, water-courses, etc. But to make such a map of the United States on a scale large enough for practical needs is a vast undertaking. The area of the United States, including Alaska, is 3,600,000 square miles, an area exceeding that of all Europe. Geographers had dreamed of a map of this vast territory. Nay, estimates of its cost had been made and submitted to Congress, but the estimated cost was so great as to be prohibitive. One class of people insisted that only a large scale, detailed, accurate and therefore expensive map was worth making. This or nothing they argued. Confronted with this theory the Geological Survey found a condition. Maps it must have for its work, and accordingly under legislative authority it set about making them. The costly methods of the European surveys were inapplicable and were rejected. The elaborate large scale maps of the Coast Survey were not needed for the geological work, and hence the methods used in their production were not adapted to this new need. The old Western surveys of Hayden, Powell and Wheeler had done map work extensively in the West, and from these surveys there came into the Geological Survey a small band of trained surveyors accustomed to rapid, sketchy, mountain work over large areas. This body of men formed the nucleus of a surveying corps, which under the sym-

pathetic and stimulating guidance and skilful leadership of Major Powell set about the task of adapting and improving old and inventing new methods to hasten and cheapen the mapping of the United States. Various experiments were tried, resulting in rapid and continuous improvements in methods. At the same time map-making went swiftly and merrily on. Many thousands of square miles were mapped each year in the Far West and in the imperfectly known Appalachians, of which there existed only either very general small scale maps or none at all. These Appalachian surveys, undertaken by the U. S. Geological Survey, were on a scale of 1:125,000, or about two miles to one inch, and while the main peaks, ridges, etc., were located by triangulation, the details were shown much generalized, all minute detail being ignored. These maps were hailed with delight by geologists and engineers engaged in studying and developing the region. For projecting railroads, opening new coal fields and iron mines they were repeatedly declared to be of great value. But the education of the map users was rapid, and soon the demand came for more detail and larger scales. The old "battle of the scales," which raged so violently in the Ordnance Survey of Great Britain in the "fifties," raged in a small way in the Geological Survey. In certain areas the scale was enlarged to 1:62,500, or about one mile to one inch, and in the Appalachians an increasing amount of detail was shown on the "two-mile" maps. Thus the later work was more detailed and more precise than the earlier, as has been the history of all national surveys. Then came revision of the earlier work, and in some cases the whole area was gone over again. But the importance of keeping the scale down to the smallest practicable limit has never been lost sight of. And in deciding upon the scales to be adopted much weight has been given to the practical requirements of the Survey itself, and small weight to European or other precedents, because of the very unlike conditions. With enlarged scales comes enlarged cost. The Survey has therefore resisted the pressure for enlarged scales, a pressure which has come both from within and without, and with a few trifling exceptions has published no maps on a larger scale than 1:62,500, or about one inch to one mile.

The total area mapped during the 12 years, 1883–1894, is in round numbers 609,000 square miles, an area equalling about one-fifth of the United States (Alaska excluded), and is comprised in 906 atlas sheets, of which 121 were produced during the fiscal year 1893–'94. The area mapped, depending on various causes, such as the scales used, the amount of money appropriated, etc., has ranged from 15,000 to 82,000 square miles per year.

Progress in topographic mapping during 12 years, 1883 to 1894, is shown in the following table in which the relative amounts on the three scales used are shown by percentages:

YEAR.	SQ. MILES.	PERCENTAGE ON SCALE OF		
		1:250,000	1:125,000	1:62,500
1883.....	15,000	73	27	0
1884.....	45,000	53	46	1
1885.....	57,000	33	63	4
1886.....	82,000	23	72	5
1887.....	56,000	25	66	9
1888.....	52,000	26	67	7
1889.....	64,000	20	70	10
1890.....	68,000	0	83	17
1891.....	65,000	0	74	26
1892.....	53,000	0	85	15
1893.....	26,000	0	27	73
1894.....	36,000	3	31	66

Surveys more or less extensive have been made in nearly every State and Territory. Massachusetts, Rhode Island, Connecticut, New Jersey and Columbia (if the District of Columbia may be so called) are completely mapped. Large tracts have been surveyed in California, Nevada, Utah, Arizona, New Mexico, Montana, Texas, Colorado, Kansas, Missouri and Arkansas. The Appalachian Mountains are nearly all mapped, and considerable tracts are also mapped in Louisiana, Oklahoma, North and South Dakota, Iowa, Illinois, Wisconsin, New York, Maine and Pennsylvania.

The atlas sheets of this great mother map of the country are now to be seen in various public libraries, so that it is perhaps needless to describe them other than to say that they are of uniform size, about 16 by 20 inches, that they are projected without reference to political divisions, that they are printed in three colors, and are designed with a view to make them as legible and as useful as possible, not merely to the geologist and engineer, but to every map user; and this means everybody, for who is not a user of maps?

Thus far we have spoken only of topography and topographic maps, the occasion for this being the large proportion of time, money and energy given by the Geological Survey to this class of work. Why so much energy should be devoted by a geological survey to the production of topographic maps may not be self-evident, and hence a word or two of explanation.

Geology is concerned with the rind or skin or crust of this ball on which we live. Out of this rind come many useful things. The iron, coal and other minerals dug out of it last year were worth 609 million dollars. It is the business of the geologist to study this crust, to map out, *i. e.*, picture out, for *mappa* means a picture, the beds or layers of material composing it, to find out the position and thickness of the beds of limestone and sandstone, of the clays, gravels, coals and ores, of the lavas and granites and the distribution of underground gas, oil, brine and water. For this work maps are of the utmost importance, both for the study and for exhibiting the results of the study. The State geologists who, in various States during the past, and present as well, have prosecuted geologic work, have unanimously regretted the lack of this powerful aid to their work. In European countries this need was never keenly felt since military needs had produced topographic maps before the geologic want was felt. Thus the European geologist found maps ready to hand. In the United States, however, the need of topographic maps has been and is for peaceful rather than for warlike pursuits. It is the geologist and engineer rather than the soldier whose demands have produced such maps as we now have. The Geological Survey, confronted with this need, has proceeded to meet it and to make, under authority of law, a topographic as well as a geologic map, and it is thus in fact though not in name the U. S. Topographic and Geologic Survey.

This need of topographic maps has delayed the production of geologic maps, and it is only in the past year or two that the Survey has been able to conclude upon the multifarious and complex questions which required decision before the publication of the first sheet of the great geological atlas of the United States was possible. Questions of classification could only be adjusted after the collection and comparison of a considerable body of facts, gathered from a wide area. But after much study, after many and lengthened conferences by men of diverse views and experience, after various comparisons and compromises, a system of classification intended for the whole country has been agreed upon, a color and pattern scheme adopted and a beginning made in publication. On the first of July, 1894, five folios had been printed and 39 more were in various stages on their way to final publication, some of them being nearly finished, others barely begun, and still others in various intermediate stages.

The final outcome of the geological surveys and studies of any district are to be shown in what are technically known as *folios*.

To clearly understand what a folio is one should be seen. But as it is impracticable to place a copy in the hands of every reader of this article, the following condensed and imperfect description must be substituted:

A geological *folio* of the U. S. Geological Survey is a large thin atlas in a cover of heavy manilla paper. On this cover is the imprint *Department of the Interior, U. S. Geological Survey*, followed by the name of the Director, and then the words *Geological Atlas of the United States.* This is followed by the name of the sheet, such as *Sacramento Sheet, California*, or *Kingston Sheet, Tennessee*, etc. A skeleton map on small scale shows the general region of country surrounding the sheet, while a shaded area on the skeleton shows the particular spot or area whose topography and geology is exhibited within the folio. A table of contents follows, called *List of Sheets*, usually 7 or 8 in number. Printed on the inside of the cover of each folio is a very simple and elementary description of the geologic map of the United States. It aims to tell in the simplest manner the leading facts about this map. *Explanatory Text* it is called in print, but Kindergarten text is its nickname. It begins "A map showing the watercourses and the unevenness of the surface is a topographic map," and farther on is added "A map showing the distribution of rock masses is a geologic map." This "kindergarten" text is sometimes, though not always, followed by a general account of the geology of the region or district within which the specific sheet lies, a description of its structure and an explanation of its supposed origin and history. This description is aimed at neither the infant nor the philosopher, but is designed for the general reader, and accordingly is as free from technical words as the subject will permit. In the case of the Sacramento Sheet, California, this descriptive text is entitled *Outlines of the geology of the gold belt;* in the Kingston Sheet, Tennessee, it is entitled *Outlines of Appalachian history.*

Of the three groups of text the last is called *Descriptive Text*, and it deals specifically with the atlas sheet which it accompanies. This text is, from the needs of the case, the most technical of all, and yet it is not needlessly technical.

These three groups of text are followed by three, usually or sometimes, four maps, each covering the same area. So many facts are to be shown that if all were printed on one sheet, there would be crowding and obscurity. The first is the topographic map which has already been briefly described. The second is devoted to *Areal Geology*, and by colors and patterns shows the distribution

of the various rock masses which form the surface of the country, or rather, perhaps, it should be said of the rocks just beneath the layer of soil made by their disintegration. The third map, entitled *Economic Geology*, is similarly covered over with patterns and bands or patches of color, showing the distribution of rock masses, but differs from the preceding in showing certain ones more conspicuously. The masses selected for emphasis are those with which deposits of known economic importance are associated. Those masses with which worked or workable iron ores are associated are shown in a strong red color; those containing coal, in blue; those containing gold, in yellow, etc. The fourth map is entitled *Structure Sections*. If the reader will imagine a trench half a mile or more deep, with vertical walls, to be dug across the country shown on the map, and then take an imaginary walk through this imaginary trench, looking at its walls, he will see, in imagination, what the geologist is trying to show in this structure section map. He will get a side view, as it were, of the crust, or of the skin on the crust. He will see whether the rock masses are beds of coal or limestone or sandstone, and whether they are lying level or sloping or are bent, folded or irregularly twisted or crushed. The last leaf of this folio is a diagram entitled *Columnar Sections*, whereon is shown the geologic age and the thickness of the different rock masses to be found as we go downward into the crust.

This short description must suffice, all imperfect as it is, and as, indeed, it would still be, though it were longer and better. It will have served an useful purpose if it quicken some reader's curiosity to call at his nearest public library and see for himself.

The long and laborious work preliminary to beginning the publication of these folios is now accomplished. Publication has actually begun and is going forward with increasing speed. More than 100 manuscript sheets are in hand and the work of publication is in progress on nearly two score of them.

This article has already grown to its full limit, and I therefore hasten to conclude.

During the year 1893–'94 the Geological Survey published its usual annual report and its usual volume on what is colloquially known as *mineral statistics*, but officially as Mineral Resources of the United States. The total value of the mineral products for the year was $610,000,000. It published 3 monographs and 17 bulletins, ranging from a thin paper-bound pamphlet to a stout quarto volume. It engraved and printed 69 topographic maps and 5 geologic folios. It made 192 chemical analyses. It increased its library,

almost exclusively by exchanges, from 104,000 to 110,000 pieces (books, pamphlets and maps), and now has a collection of works on geology in general and of the United States in particular that is without an equal.

And lastly, it has a new director selected from its own corps for merit alone, and who succeeds an older, a skilful and a successful leader. Thus he is exposed to criticism by contrast. That such criticism has not come is one of the strongest evidences of the wisdom of the choice and one of the best auguries for the future.

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